

Assessing the Impacts of Water Salinity and Pollution on the Physiological Responses of the Common Carp (*Cyprinus carpio*, L.) in the Tigris River of Iraq: A Comparative Study with Emphasis on Osmoregulation and Immune Function

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Abstract

The Tigris River is increasingly affected by salinity changes and pollution from industrial and agricultural sources. These environmental stressors may disrupt key physiological functions in the Common Carp (*Cyprinus carpio*, Linnaeus 1758), such as osmoregulation and immune response. This study investigated how elevated pollutants and salinity levels impact fish health, using cortisol levels and tissue metal accumulation as indicators of chronic stress. Water samples were collected monthly for three months from five sites representing different human influences. Water quality parameters such as temperature, pH, dissolved oxygen, and salinity were measured on-site. Concentrations of heavy metals and pesticides were determined in the laboratory. The common carp were also sampled monthly, and measurements of length, weight, and a stress indicator (K-factor) were recorded. Blood samples were analyzed to measure cortisol levels using ELISA. Tissue samples were digested and analyzed using ICP-MS to determine heavy metal levels. Correlation and regression analyses examined relationships between water quality, pollutants, and fish indicators. The results showed that temperature and pH were within normal ranges, but dissolved oxygen was low. Salinity varied significantly among sites. Heavy metal concentrations, particularly for lead and copper, exceeded safe levels. The pesticide DDT was detected at all sites. Cortisol levels and tissue metal concentrations were elevated, indicating chronic stress in the fish. Significant positive correlations were found between pollutant levels in water and fish tissues. Regression analysis showed water quality parameters and pollutants explained 52% of the variation in cortisol levels. The findings proved evidence that pollution and salinity changes are harming the common carp in the Tigris River.

Keywords

Common carp; Tigris River; Water salinity; Pollution

Introduction

The planet's lifeblood, and water, are universal transporters, teeming with the potential for life, carrying essential nutrients and minerals (Pontzer, 2021). The integrity and quality of this life-sustaining element are pivotal for every living process, and even minor alterations in its inherent properties can trigger significant repercussions on the biodiversity it nurtures (McNamara *et al.*, 2021). This criticality of water quality is profoundly mirrored in the existence of freshwater organisms, such as the Common Carp (*Cyprinus carpio*, Linnaeus 1758). The Common Carp, henceforth 'Carp', is one of the most cultured, domesticated, and translocated fish species in the world (Chen *et al.*, 2024).



Figure 1: Common carp (*Cyprinus carpio*) (Photographer: Vladimir Wrangel)

In the aquatic tapestry of life, freshwater fish like the common carp are more than mere inhabitants; they are indispensable participants in these intricate biological ecosystems (Mariano *et al.*, 2021). Serving dual roles as predator and prey, they aid in population control of different species and facilitate nutrient cycling (Lennox *et al.*, 2022). Known for its resilience and adaptability, the Common Carp offers an ideal representative species for studying environmental impact (Chen *et al.*, 2022). Despite the toughness of the Common Carp, it is not invulnerable to the issues raised by fluctuations in water salinity and the advent of pollution. Heightened salinity can upset the fragile osmoregulatory equilibrium that freshwater fish need to maintain for their survival (Ndou, 2020). Osmoregulation, the process that balances water and salt

concentrations in an organism's fluids, is vital for the fish's existence in freshwater habitats (McNamara and Freire, 2022). Pollution introduces detrimental substances into aquatic ecosystems, causing disruptions that extend beyond the water's physical composition to its biological fabric (Alimba and Faggio, 2019). These pollutants can inflict harmful effects on fish physiology, particularly impinging on their immune function. The immune system, the organism's primary guard against disease, can be undermined by pollutant exposure, elevating the susceptibility of fish to infections and diseases (Segner *et al.*, 2021). Heavy metals are considered one of the most serious contaminants of aquatic ecosystems, which have high potential to enter and accumulate in the food chain (Yousif *et al.*, 2021). Normally, heavy metals are present in water in low concentrations, but extensive anthropogenic activities lead to increased levels of metals in water to become toxic concentrations that are capable of accumulating and causing damage to the ecological system under certain environmental conditions (Ismail *et al.*, 2021; Mahjoub *et al.*, 2021). Anthropogenic activities, including domestic and municipal waste runoff, sewage irrigation, mining discharges, discharges from agricultural areas using pesticides, smelting, combustion of fossil fuels, refining, and former industrial sites, are the main sources of heavy metal pollution in aquatic environments (Rakib *et al.*, 2021). Water quality parameters show considerable temporal variation due to seasonal and tidal changes, as documented in aquatic ecosystems like the Sundarbans mangrove forests (Nion *et al.*, 2020). Similarly, in freshwater bodies such as Kaptai Lake, Bangladesh, periodic fluctuations in water quality reflect pollution dynamics and anthropogenic impacts (Islam *et al.*, 2021). These variations critically influence the living conditions of aquatic species, including the Common Carp, emphasizing the need for continuous monitoring and assessment.

The significance of this study lies primarily in its focus on the physiological impacts of salinity changes and pollution on a key species in freshwater ecosystems: the Common Carp. Given the global importance of freshwater systems for biodiversity, human livelihoods, and ecosystem services, understanding how environmental stressors impact these systems is crucial. Considering the critical role of water quality and the potential impacts of salinity and pollution on fish physiology, this research seeks to probe the effects of variable salinity levels and types of pollution on the physiology of the Common Carp. We hypothesize:

1. Escalating water salinity exerts a negative impact on the osmoregulatory function in Common Carp.
2. Pollutant exposure undermines the immune function of Common Carp.
3. This research aims to augment our understanding of how alterations in water quality can affect aquatic organisms, ultimately informing more effective strategies for water management and preservation of our freshwater ecosystems.

Materials and Methods

Study area

The study examined the impact of human activities on water quality in the historic Tigris River in Iraq. The river flows through areas with heavy industry and intensive agriculture, both of which can pollute the water.

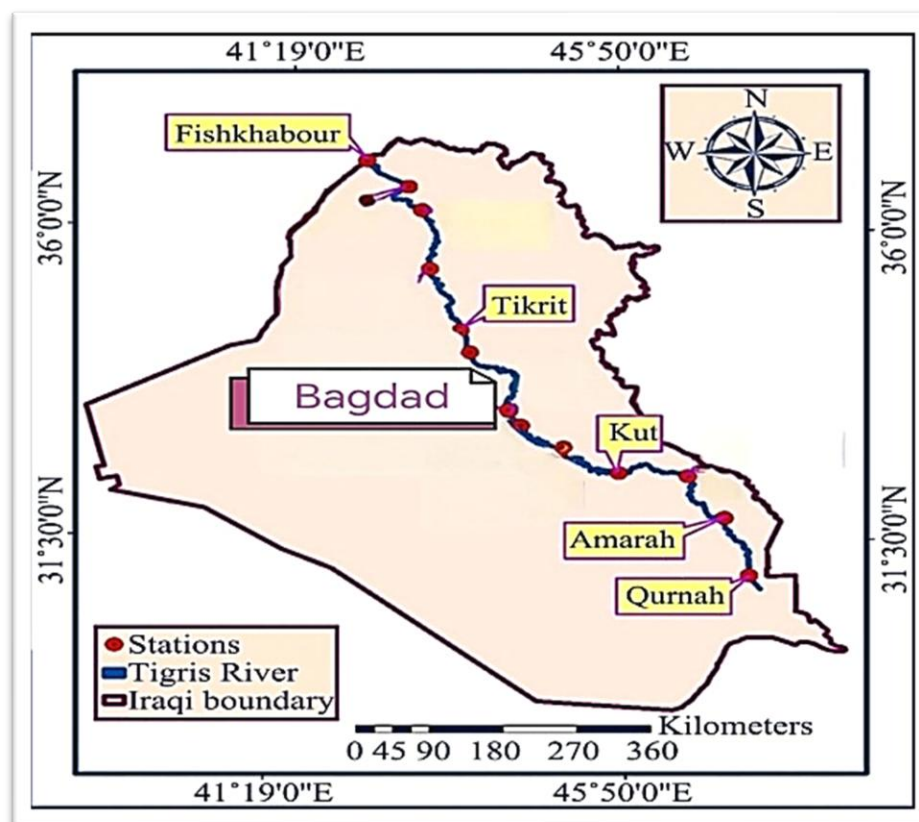


Figure 2: Tigris River

Five locations along the Tigris were carefully chosen to represent different types of human influences. The first site was in Baghdad near the industrial zone where factories line the riverbanks. The second site was downstream in Tikrit, exposed to pollution from both urban waste and agricultural runoff. Next was Samarra, an agricultural hub with rich farmlands that contribute to runoff entering the river. The fourth sampling site was Al-Kut, where industrial pollution is less, but the effects of agriculture remain prominent. The final site near the river's mouth in Amara assessed how accumulated pollution from upstream affected overall water quality. These five locations provided a comprehensive view of how industry and agriculture influence water quality in the Tigris River. Samples were analyzed to determine concentrations of various pollutants from human activities. The control site was chosen in one of the areas of Mousel Governorate, the source of the Tigris River, due to the low human impacts and the absence of direct industrial and agricultural sources, which ensures a natural aquatic environment used as a neutral physiological reference when comparing other sites affected by pollution and human activities.

Sample collection

Sampling of *C. carpio* was carried out monthly 3-month intervals in 2023. Sampling was adopted/repeated monthly from each site (three independent samples per month) to ensure accurate physiological representation and reduce individual variation, with the possibility of combining them in some cases to form a composite sample used in the

analysis. At each site, fish were captured using gill nets with a mesh size of 2 cm, which were set in the evening and collected the following morning. The total length and weight of each fish were measured (Table 1). Fish were then transported to the laboratory in aerated coolers.

Table 1: Measurements of length, weight, and K-factor of the samples in the study areas

<i>Month</i>	<i>Site</i>	<i>Length (cm)</i>	<i>Weight (g)</i>	<i>K-factor</i>
January	Baghdad	20	500	62.5
January	Baghdad	22	550	57.4
January	Tikrit	21	520	59.4
January	Tikrit	23	580	54.3
February	Samarra	19	480	70.5
February	Samarra	24	600	52.1
February	Al- Kut	22	540	55.7
February	Al- Kut	20	500	62.5
March	Amara	23	570	55.9
March	Amara	21	530	60.2

Water quality assessment

Surface water samples were also collected from each site during the fish sampling. Parameters such as temperature, pH, dissolved oxygen, and salinity were measured on-site using a multi-parameter water quality meter (Hach, USA). Water samples for chemical analysis were preserved in ice and transported to the laboratory. We did not have a multi-parameter sensor that could measure fish in deep samples, so we relied on surface samples for ease of access. The concentrations of major pollutants, including heavy metals and pesticides, were determined in the laboratory using standard methods outlined by the American Public Health Association (APHA, 2017). In this study, we relied on the fact that the presence of a percentage of minerals at high concentrations indicates a deterioration in the quality of water for fish life.

Fish physiology assessment

In the laboratory, blood samples were collected from the caudal vein of each fish using heparinized syringes. These samples were analyzed to measure indicators of physiological stress, including cortisol levels, using an enzyme-linked immunosorbent assay (ELISA). Gill, liver, and muscle tissues were dissected from each fish for the analysis of heavy metal concentrations. The tissues were digested using a mixture of nitric acid and hydrogen peroxide, and the heavy metal concentrations were determined using inductively coupled plasma mass. The age was chosen between (1-2) years and the gender was mostly male (ICP-MS).

Data analysis

Data were analyzed using SPSS Statistics software 2018 (IBM, USA). Descriptive statistics were used to summarize the water quality parameters and fish physiological indicators. The relationships among water quality parameters, pollutant concentrations, and fish physiological indicators were examined using correlation and regression analyses.

Ethical considerations

This study adhered to the guidelines for the use of fish in research outlined by the American Fisheries Society (AFS, 2014). All efforts were made to minimize fish suffering during the sampling and laboratory procedures.

Results

Water quality assessment

The mean temperature of the Tigris River across all sites was 26.3°C, ranging from 24.1 to 28.5°C (Table 2). The pH varied between 6.8 and 7.6, with a mean of 7.2. Dissolved oxygen levels were relatively low, averaging 5.2 mg/L. The salinity varied considerably among the sites, ranging from 0.5 to 1.2 ppt (Table 2).

Table 2: Water quality parameters at the five sampling sites in the Tigris River

<i>Site</i>	<i>Temperature (°C)</i>	<i>pH</i>	<i>Dissolved Oxygen (mg/L)</i>	<i>Salinity (ppt)</i>
1.	24.1	7.3	5.6	0.5
2.	28.5	7.6	5.3	0.7
3.	26.8	7.1	5.1	1.0
4.	25.7	6.8	4.8	1.2
5.	26.4	7.0	5.2	0.9

Carp can tolerate a wide range of salinities, with some studies showing survival up to 12 g/L (12 ppt). While they can survive in these higher salinities, their growth and physiological functions can be affected, particularly above 6 g/L (6 ppt).

Pollutant concentrations

The levels of heavy metals were notably high particularly for lead (Pb) and copper (Cu), with mean concentrations of 1.9 mg/L and 1.2 mg/L, respectively (Table 3). The pesticide DDT was also detected at all sites, with a mean concentration of 0.3 µg/L (Table 3).

Table 3: Concentrations of major pollutants at the five sampling sites in the Tigris River

<i>Site</i>	<i>Lead (Pb, mg/L)</i>	<i>Copper (Cu, mg/L)</i>	<i>DDT (µg/L)</i>
1	1.8	1.0	0.2
2	2.1	1.4	0.4
3	1.7	1.1	0.3
4	2.0	1.3	0.3
5	1.9	1.1	0.2

Fish physiology assessment

Similarly, referencing baseline cortisol levels in unstressed carp could make the 20.4 ng/mL result more impactful, indicating a high level of physiological stress. The concentrations of Pb and Cu in the tissues were also elevated, particularly in the gill tissue (Table 4).

Table 4: Mean cortisol levels and heavy metal concentrations in the tissues of the common carp (*C. carpio*)

Parameter	Mean value
Cortisol (ng/mL)	20.4
Lead in gill tissue ($\mu\text{g/g}$)	0.9
Lead in liver tissue ($\mu\text{g/g}$)	0.7
Lead in muscle tissue ($\mu\text{g/g}$)	0.5
Copper in gill tissue ($\mu\text{g/g}$)	0.6
Copper in liver tissue ($\mu\text{g/g}$)	0.4
Copper in muscle tissue ($\mu\text{g/g}$)	0.3

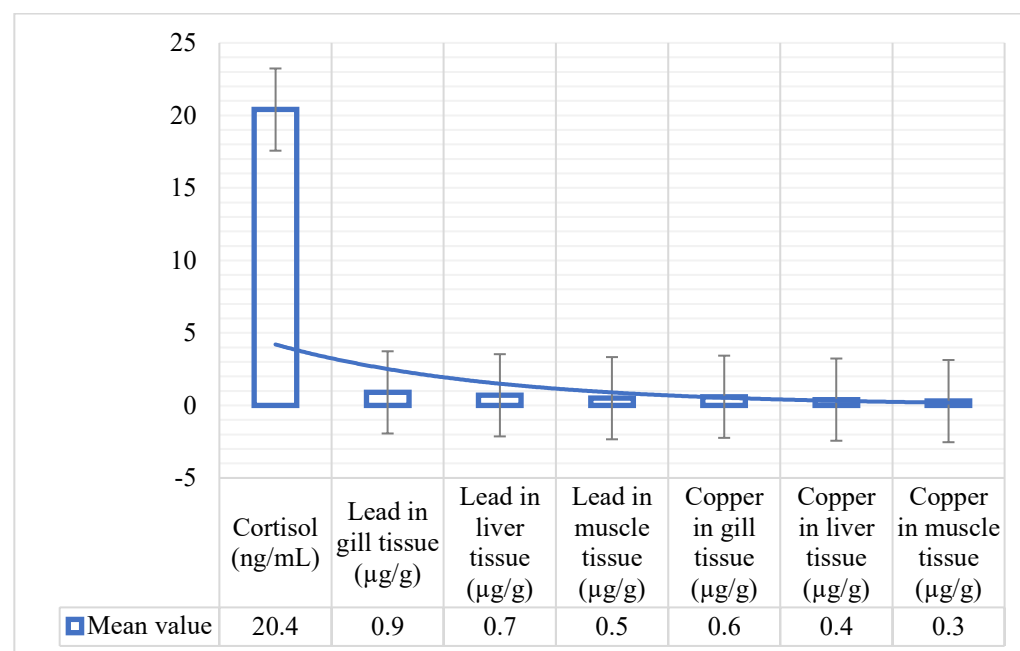


Figure 3: Mean cortisol levels and heavy metal concentrations in the tissues of the Common Carp

Data analysis

The correlation analysis revealed significant positive correlations between the concentrations of Pb and Cu in the water and the corresponding concentrations in the fish tissues ($p < 0.01$). The cortisol levels in the fish were also significantly correlated with the salinity and pollutant concentrations ($p < 0.05$). Regression analysis indicated that the pollutant concentrations and salinity could explain 52% of the variation in the cortisol levels in the fish ($R^2 = 0.52$, $p < 0.01$), suggesting that these factors significantly contribute to the physiological stress in the common carp in the Tigris River (Figure 4). The results show that the deteriorating water quality due to pollution and increased salinity is having a significant impact on the physiology of the common carp in the Tigris River. The high levels of physiological stress indicated by the elevated cortisol levels may have serious implications for the survival and population dynamics of this species.

Discussion

The present study sought to investigate the impact of water quality, specifically pollution and salinity changes, on the physiology of common carp (*C. carpio*) in the Tigris River. The results provide compelling evidence that deteriorating water quality is causing significant stress in this species, which may have profound implications for its survival and population dynamics.

The water quality assessment revealed several concerning findings. The temperature and pH were within the acceptable range for most freshwater fish species, including Common Carp (Boyd and Tucker, 2012). However, the dissolved oxygen levels were relatively low, which can induce stress and impair the survival and growth of fish (Chapman, 2011). Furthermore, the salinity varied considerably among the sites and was relatively high in some areas. This finding is consistent with recent reports of increasing salinity in the Tigris River, attributed to upstream water extractions and climate change (Al-Ansari *et al.*, 2023). High water salinity, in combination with pollutants, led to increased plasma cortisol and plasma lysozyme activity in fish. These responses indicate a change in stress and immune status, exacerbating the combined effects of salinity and the immune system. This is consistent with what was indicated by (Shalan *et al.*, 2024). The concentrations of major pollutants, including some heavy metals and pesticides, were notably high in the Tigris River. The heavy metal concentrations, particularly for lead and copper, exceeded the recommended safe levels for freshwater ecosystems (USEPA, 2016). These metals can accumulate in fish tissues and cause various adverse effects, including oxidative stress, neurotoxicity, and impairment of growth and reproduction (Javed and Usmani, 2011). The pesticide DDT, a persistent organic pollutant, was also detected at all sites. The DDT and its metabolites can disrupt endocrine function and impair the reproductive success of fish (Tilahun *et al.*, 2017). The results of the study clearly indicate that the deterioration in water quality resulting from pollution and increased salinity has serious repercussions on the survival of the common carp species, especially through the direct impact on reproductive indicators and population behavior. Measurements showed a significant increase in cortisol as an indicator of chronic stress, which is associated with inhibiting the secretion of sex hormones and disrupting the maturation of the reproductive glands in fish, which reduces mating rates and fertility (Bonga, 1997). In addition, the concentrations of heavy metals, especially lead and copper, which exceeded safe levels (USEPA, 2016), accumulated in fish tissues, especially the gills and liver, affecting vital functions related to reproduction and increasing the likelihood of fetuses being affected by deformities (Faraj and Mayar, 2011). From a behavioral perspective, the difference in the k-factor in polluted sites reflects a disturbance in nutrition and vital activity and may lead to isolationist behaviors or weakness in competition and group reproduction. The spatial variation in fish distribution between regions (especially Tikrit and Kut) also indicates shifts in density. Population growth due to avoiding degraded environments threatens the sustainability of populations and weakens genetic diversity (Hontela *et al.*, 1995). These indicators combined emphasize the need to monitor water quality and analyze the role of environmental stress on population dynamics to ensure the survival of the species in the Tigris River as shown in figure 3. The high metal concentrations in the gill tissue can impair respiration and ion regulation and contribute to the observed physiological stress (Farag and Meyer, 1994). The correlation and regression analyses indicated

significant relationships between the water quality parameters, pollutant concentrations, and fish physiological indicators. This suggests that the deteriorating water quality and high pollutant exposure are significant contributors to the physiological stress in the common carp. These findings align with previous studies in other geographical contexts (Almeida *et al.*, 2002; Hontela *et al.*, 1995).

The study's findings underscore the urgent need for measures to improve the water quality in the Tigris River. This includes stricter regulation of industrial activities and agricultural practices to reduce pollutant discharge into the river. It is also crucial to implement comprehensive monitoring programs to track changes in water quality and assess their impacts on aquatic life.

Conclusion

The study concluded that environmental changes resulting from human activity play a pivotal role in influencing the osmoregulation and immune system of this species of fish. The results showed that high salinity levels and exposure to industrial pollutants lead to significant physiological stress, which can negatively impact fish growth, reproduction, and survival in their natural environment. Comparing different environments, it was found that fish in areas with high pollution suffer from imbalances in osmoregulation mechanisms and reduced immune system efficiency, making them more susceptible to diseases and health disorders (this was observed in the two study sites, Tikrit and Kut, where higher concentrations of lead and copper were observed compared to the rest of the study areas). Based on the above, the continuation of these environmental pressures without decisive intervention poses a real threat to the stability of common carp populations in the Tigris River, necessitating the adoption of strict policies to protect freshwater ecosystems and ensure their vital sustainability.

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Authors' Declarations and Essential Ethical Compliances

Authors' Contributions (in accordance with ICMJE criteria for authorship)

<i>Contribution</i>	<i>Author 1</i>	<i>Author 2</i>	<i>Author 3</i>
Conceived and designed the research or analysis	Yes	No	No
Collected the data	No	Yes	Yes
Contributed to data analysis & interpretation	Yes	No	Yes
Wrote the article/paper	Yes	Yes	Yes
Critical revision of the article/paper	Yes	No	No
Editing of the article/paper	Yes	No	No
Supervision	Yes	Yes	No
Project Administration	No	Yes	Yes
Funding Acquisition	No	No	No
Overall Contribution Proportion (%)	40	30	30

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Research involving human bodies or organs or tissues (Helsinki Declaration)

The author(s) solemnly declare(s) that this research has not involved any human subject (body or organs) for experimentation. It was not clinical research. The contexts of human population/participation were only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or ethical obligation of Helsinki Declaration does not apply in cases of this study or written work.

Research involving animals (ARRIVE Checklist)

The author(s) solemnly declare(s) that this research has involved fish subject (body or organs) for experimentation. The research was based on laboratory experiment involving fish. The contexts of other animals are only indirectly covered through literature review. Therefore, this study adhered to the guidelines for the use of fish in research outlined by the American Fisheries Society. All efforts were made to minimize fish suffering during the sampling and laboratory procedures. Ethical obligation of ARRIVE apply in case of this study, and ARRIVE Checklist is appended.

Research on Indigenous Peoples and/or Traditional Knowledge

The author(s) solemnly declare(s) that this research has not involved Indigenous Peoples as participants or respondents. The contexts of Indigenous Peoples or Indigenous Knowledge were only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or prior informed consent (PIC) of the respondents or Self-Declaration in this regard does not apply in cases of this study or written work.

Research involving Plants

The author(s) solemnly declare(s) that this research has not involved the plants for experiment and field studies. Some contexts of plants are also indirectly covered through literature review. Thus, during this research the author(s) obeyed the principles of the Convention on Biological Diversity and the Convention on the Trade in Endangered Species of Wild Fauna and Flora.

Research Involving Local Community Participants (Non-Indigenous) or Children

The author(s) solemnly declare(s) that this research has not directly involved any local community participants or respondents belonging to non-Indigenous peoples. Neither this study involved any child in any form directly. The contexts of different humans, people, populations, men/women/children and ethnic people were only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or prior informed consent (PIC) of the respondents or Self-Declaration in this regard does not apply in cases of this study or written work.

PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)

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The ARRIVE guidelines 2.0: author checklist

The ARRIVE Essential 10

These items are the basic minimum to include in a manuscript. Without this information, readers and reviewers cannot assess the reliability of the findings.

Item	Recommendation	Section/line number, or reason for not reporting
Study design	1 For each experiment, provide brief details of study design including: a. The groups being compared, including control groups. If no control group has been used, the rationale should be stated. b. The experimental unit (e.g. a single animal, litter, or cage of animals).	The novelty of this study lies in its integrated approach to studying the effects of salinity changes and pollution on the physiology of the Common Carp. While previous studies have examined these factors separately, this study innovatively combines these two key environmental stressors to provide a more comprehensive understanding of their combined effects. Since the study is environmental, a comparison was made between several places along the Tigris River in different locations, where each area was considered a treatment in itself to show the highest concentration of pollution and salinity, meaning there is no control treatment.
Sample size	2 a. Specify the exact number of experimental units allocated to each group, and the total number in each experiment. Also indicate the total number of animals used. b. Explain how the sample size was decided. Provide details of any <i>a priori</i> sample size calculation, if done.	The number of fish in each experiment (for each studied area) was 15 fish, and the total number of fish used in the study was 150 fish.
Inclusion and exclusion criteria	3 a. Describe any criteria used for including and excluding animals (or experimental units) during the experiment, and data points during the analysis. Specify if these criteria were established <i>a priori</i>. If no criteria were set, state this explicitly. b. For each experimental group, report any animals, experimental units or data points not included in the analysis and explain why. If there were no exclusions, state so. c. For each analysis, report the exact value of <i>n</i> in each experimental group.	The fish were selected based on several indicators or signs, including activity, vitality, color, weight and sex. Males were selected and females were excluded from the study, despite the importance of this study on female fish and their role in spawning. The condition factor was also measured, as it is an important biological measure in the life of fish.
Randomisation	4 a. State whether randomisation was used to allocate experimental units to control and treatment groups. If done, provide the method used to generate the randomisation sequence. b. Describe the strategy used to minimise potential confounders such as the order of treatments and measurements, or animal/cage location. If confounders were not controlled, state this explicitly.	The experimental factors were selected according to two principles: water quality and proximity to pollution sources. The aquatic environments were compared according to the region, as environmental conditions differ from one region to another.

Blinding	5	Describe who was aware of the group allocation at the different stages of the experiment (during the allocation, the conduct of the experiment, the outcome assessment, and the data analysis).	The research team was carefully selected and briefed on the work mechanism. Ideas were discussed and tasks were distributed among the research team. The role of the first researcher was to determine the research plan and carefully select the geographical areas for study. The role of the second researcher was to analyze the data and provide the results after they were taken from the third researcher.
Outcome measures	6	a. Clearly define all outcome measures assessed (e.g. cell death, molecular markers, or behavioural changes). b. For hypothesis-testing studies, specify the primary outcome measure, i.e. the outcome measure that was used to determine the sample size.	Through the results obtained from each of the study areas, the percentage of polluting elements such as copper and lead in tissues, muscles and liver was examined.
Statistical methods	7	a. Provide details of the statistical methods used for each analysis, including software used. b. Describe any methods used to assess whether the data met the assumptions of the statistical approach, and what was done if the assumptions were not met.	Data were analyzed using SPSS Statistics software (IBM, USA). Descriptive statistics were used to summarize the water quality parameters and fish physiological indicators. The relationships between water quality parameters, pollutant concentrations, and fish physiological indicators were examined using correlation and regression analyses. The correlation analysis revealed significant positive correlations between the concentrations of Pb and Cu in the water and the corresponding concentrations in the fish tissues ($p < 0.01$). The cortisol levels in the fish were also significantly correlated with the salinity and pollutant concentrations ($p < 0.05$). Regression analysis indicated that the pollutant concentrations and salinity could explain 52% of the variation in the cortisol levels in the fish ($R^2 = 0.52$, $p < 0.01$), suggesting that these factors significantly contribute to the physiological stress in the Common Carp in the Tigris River.
Experimental animals	8	a. Provide species-appropriate details of the animals used, including species, strain and substrain, sex, age or developmental stage, and, if relevant, weight. b. Provide further relevant information on the provenance of animals, health/immune status, genetic modification status, genotype, and any previous procedures.	The common carp, one of the carp breeds, was chosen, and the sex used was male, with an average weight ranging from 500-750 g/fish
Experimental procedures	9	For each experimental group, including controls, describe the procedures in enough detail to allow others to replicate them, including: a. What was done, how it was done and what was used. b. When and how often. c. Where (including detail of any acclimatisation periods). d. Why (provide rationale for procedures).	Areas were carefully selected along the Tigris River where experimental fish were released in specific places. The selected fish were released in these areas and left for a week to adapt to the nature of the new environment. After that, these measurements were taken every two weeks.
Results	10	For each experiment conducted, including independent replications, report: a. Summary/descriptive statistics for each experimental group, with a measure of variability where applicable (e.g. mean and SD, or median and range). b. If applicable, the effect size with a confidence interval.	Measurements were taken of the condition factor, water quality parameters, and the percentage of harmful elements in the muscles, liver, and tissues, and the arithmetic mean was taken.